International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 2, February 2017, pp. 190–198 Article ID: IJCIET_08_02_021
Available online at http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=2
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

A STUDY ON THE IMPACT OF BLAST LOADING FOR NUCLEAR EXPLOSION ON STRUCTURES

D. Yogeswar
M.Tech Student, Computer Aided Structural Engineering, JNTUA College of Engineering (Autonomous), Ananthapuramu, Andhra Pradesh, India

Dr. C. Sashidhar
Professor, Department of Civil Engineering, JNTUA College of Engineering (Autonomous), Ananthapuramu, Andhra Pradesh, India

ABSTRACT

In today's geopolitical environment, the need to protect both military facilities and civilian population from enemy attack has not diminished. Furthermore, we noted an increasing need to protect civilian populations against terrorism and social and subversive unrest. Protecting society against this form of featureless evolving type of warfare will remain a challenge, at least through the first half of 21st century and certainly longer. Any outstanding recognition will require a well planned multi-layered contribute to that strikes a fine coordination between ensuring a nations security and support the freedoms that modern society enjoys. In this context, this project is done to study the impact of blast loading for nuclear explosion on buildings. On high these recommendations define the structural strength pre-eminent to withstand the force produced by a surface burst of a nuclear weapon. A brief forum of the major parameters which exercise the force acting on a structure is followed by a specification of the peak magnitude and time variation of these forces. Specific details which define the net forces acting on an element of the basic structural types are given. As this design requires a sound background on blast loading mitigations and as it not economical only. Following the discussion of the effects of the size and function of a structure is specification of basic properties of reinforced concrete and steel. The protective structural analysis is based upon the Tri Service Manual TM 5-1300, ASCE Manual 42, FEMA guidelines and Indian Standards

Key words: Blast load, nuclear explosion, blast wave parameters, effects of blast waves.

Cite this Article: D. Yogeswar, Dr. C. Sashidhar, A Study on the Impact of Blast Loading for Nuclear Explosion on Structures. *International Journal of Civil Engineering and Technology*, 8(2), 2017, pp. 190–198.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=2

1. INTRODUCTION

One of the essential needs of all living creatures is to have reliable and secure shelter. Enveloping history, humans have demonstrated an astonishing capacity to address this need. They have sophisticated characteristics to safeguard themselves against both natural disasters and hazards affiliated with manufactured activities. In 1989, the mother earth viewed a watershed incident with the

obliteration of the cold war and the former Soviet Union. The designated “Doomsday Clock” that signified the time durable for civilization was ritualistically set back. Nations across the planet began to reducing their armed personnel in confessing to the peace abridge achieved with the increased world stability. Critically, the euphoria did not exist for long. Reckoning the development of advanced weapon systems (including long range ballistic missiles that can carry nuclear, biological and chemical device), one notes a dramatic growth in international terrorism activities.

Terrorism is not a new evolvement, and one truly see through historic references range such activities existed for nearby than 2000 years. Most recent, the use of Terrorism as an operation to accomplish global objectives was a principal cause for World War 1. Aside the cold war, terrorism was underling to the combat between the superpowers. In most cases, this tactic seemed sole to civilian disputes by rival political factions within perspicacious nation states. Industrialized countries believed the annoyance of terrorism as a third world phenomenon and with perhaps the exceptions of a handful countries paid such events condensed notice.

Previous to 1993, America have been tremendously unaffected by using terrorism within its borders. Then in February 1993, the U.S. become attacked by way of externally supported terrorists who centred the arena exchange centre. In April 1995, the U.S. became stunned by means of the devastating home grown terrorist attack towards the Alfred P. Murrah Federal constructing in Oklahoma town. The activities in Sept. 11, 2001 and subsequent incidents in Indonesia, Spain and the United Kingdom validated the ability of terrorists to motive civilian deaths and belongings harm at degrees no longer visible since the waning days of global battle II. These recent bad terrorist assaults modified for all time the various federal, state and nearby government agencies in America and lots of different corporations around the arena have a look at the country wide security and the need for protection from terrorism.

Clearly, in nowadays geopolitical environment, the need to defend each military facilities and civilian population from enemy attack has no longer diminished. Moreover, we stated a growing need to guard civilian populations against terrorism and social and subversive unrest. This example is real for many parts of world and it could exceed the previous motives for the development of protective technology. not like the worldwide politically and ideologically influenced conflicts of the beyond dominated by way of well-prepared army forces, most of the armed conflicts inside the ultimate for two decades have been localized and dominated by means of social, spiritual, financial and different causes. We now not face a traditional battle with a well-described adversary and need to now remember an amorphous evolving adversary. Furthermore, societies need to learn how to cope with a special kind of war that is termed low depth war. well understood and reasonably predictable navy operations were changed via an awful lot less understood and less predictable terrorist activities executed by way of determined people or small organizations that have a huge range of backgrounds and competencies.

Defending society in opposition to this shape of rapidly evolving form of struggle will continue to be a task, at least thru the first half of 21st century and probable longer. Any a success reaction will require a proper planned multi-layered method that strikes a high-quality balance between ensuring a nations protection and maintaining the freedoms that cutting-edge society enjoys. The reasons for terrorism are associated with a large range of critical areas like tradition, records, sociology, geopolitics, economics, faith, lifestyles sciences and medication and so on., therefore, except the extreme want for modern developments in these areas, society need to invest within the development of effective skills in intelligence, law enforcement and military utility to counter such threats.

Technology can and could play a major role in those efforts and society ought to expand modern and complete protective technology. Furthermore, we should no longer employ only empirical approaches to address those troubles. The free international need to increase innovative theoretical, numerical and experimental approaches to shield from traditional guns and WMD’s (guns of Mass Destruction) and have to conduct these sports in a nicely-co-ordinated collaboration involving

authorities, academic and personal organizations. Such technologies constitute the final layers of defence between society and the threats in spite of everything different layers of defence have failed. They may be important for ensuring the safety of humans and upkeep of precious countrywide belongings.

This project is geared toward developing the foundation for permitting powerful mitigation of unusual masses, which includes the ones associated with both deliberate and unintended explosive incidents. The making plans of such activities must think about not most effective the physical environments related to the detonation of explosive devices. It ought to cope up with a common adversarial surroundings that could encompass a big quantity of parameters, considered one of which is a specific explosive tool. Furthermore, due to the fact the definition of failure is related closely to performance necessities, all associated parameters should be considered. The opposite essential elements that may impact the effectiveness of such incidents and remedies may be associated with nontechnical regions and they need to be taken into consideration inside the standard method of threat and chance assessment. The thrust of the existing discussion is to develop realistic guidelines for analysis, design, evaluation, retrofit and research in discipline of blanketed facilities.

2. BLAST WAVE PHENOMENA

This study examines the character of deeply buried facility, explores the problems associated with detecting these sites, and focuses on unconventional tactics for defeating these goals. In this the shape is to be designed for the subsequent two situations:

1) Dynamic Analysis for blast loads.

2) Static Analysis for normal loads.

2.1. Dynamic Analysis for Blast Loads

- Guidelines given in UFC are followed for the dynamic design of the structural elements using ultimate load theory.
- ANSYS analysis is carried to simulate the weapon effects and to assess the stress in various elements of the structure.

2.2. Static Analysis for Normal Loads

Limit state method as per IS: 456 are used for designing the elements of the structure for normal loads. Earth quake loads will not govern the design, since the blast loads are much severe than Seismic Loads.

The violent release of energy from a detonation converts the explosive material into a very high pressure gas at very high temperatures. A pressure front associated with the high pressure gas propagates radially into the surrounding atmosphere as a strong shock wave, driven and supported by the hot gases. The shock front, termed the blast wave, is characterized by an almost instantaneous rise from ambient pressure to a peak incident pressure P_{so}(Figure-1).

3. NUCLEAR EXPLOSION

A nuclear explosion is an explosion that takes place as a result of the speedy release of electricity from an excessive speed nuclear reaction. The reaction can be nuclear fission, nuclear fusion or a multistage cascading combination of the two even though to date all fusion based weapons have used a fission device to initiate fusion, and a pure fusion weapon stays a suppositious device.

Atmospheric nuclear explosions are related to mushroom clouds, even though mushroom clouds can occur with huge chemical explosions, and its miles viable to have an airburst nuclear explosion without those clouds. Nuclear explosions produce radiation and radioactive particles.

4. DETERMINATION OF FREE FIELD BLAST WAVES PARAMETER

The procedure for determination of free field blast wave parameter is adopted from *UFC 3-340-02.*

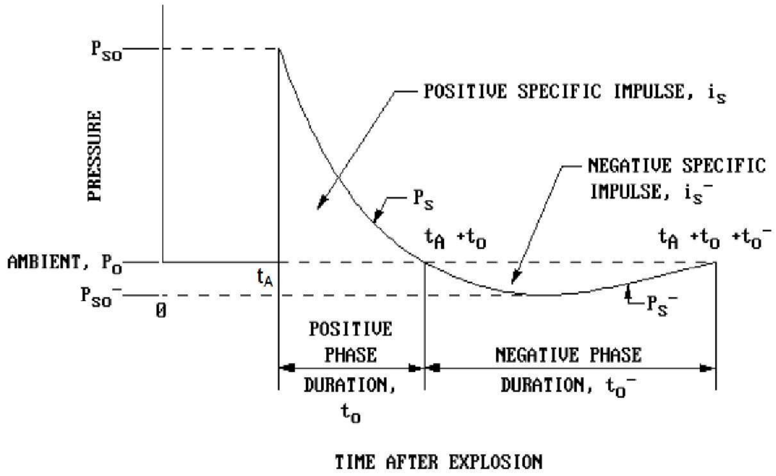

Figure 1 Blast Wave Parameters

4.1. PROCEDURE

Step 1: Select point of intersection the ground relative to the charge. Determine the charge weight and ground distance R_G.

Step 2: Apply a 20% safety factor to the charge weight.

Step 3: Calculate scaled ground distance Z_G.

$$Z_G = \frac{R_G}{W^{1/3}}$$

Step 4: Determine the free-field blast wave parameters from Figure-2 for corresponding scaled ground distance Z_G :

- Peak positive incident pressure = P_{SO}
- Shock front velocity = U
- Scaled unit Positive incident impulse = $i_s / W^{1/3}$
- Scaled positive phase duration = $t_0 / W^{1/3}$
- Scaled arrival time = $t_A / W^{1/3}$
- Multiply scale value by $W^{1/3}$ to obtain absolute values.

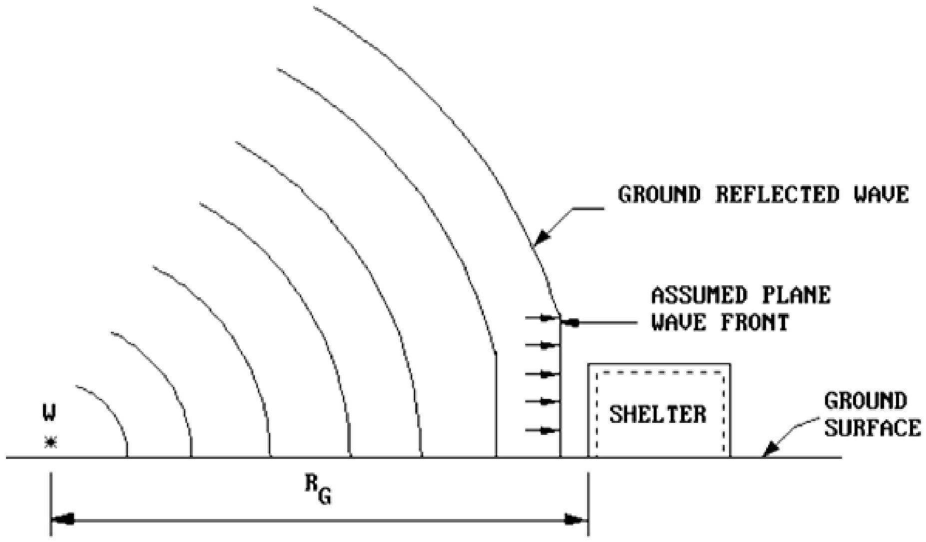

Figure 2 Surface Burst Environment

4.2. Computation of Free Field Blast Parameters

Let us consider a surface burst of 20 KT a 300m

Step 1:

Charge Weight (W)

= 20 KT

= 44105760 lbs

R_G = 300 m

= 984 ft

Step 2:

Safety Factor of 20% to

W = 24 KT

= 52926912 lbs

Step 3:

For Point of Interest

$$Z_G = \frac{R_G}{W^{1/3}}$$

$$Z_G \left[{}^{m}\!/_{KT^{1/3}}\right] = 104.00$$

$$Z_G \left[{}^{ft}\!/_{lb^{1/3}}\right] = 2.62081428$$

Step 4:

Determination of Blast wave parameters from Figure - 2

Scaled Distance

Z_G = $104\ {}^{m}\!/_{KT^{1/3}}$

$= 2.621 \, {}^{ft}/_{lb^{1/3}}$

Peak Positive Incident Pressure

P_{so} $= 1034.211 \, {}^{KN}/_{m^2}$

= 150 psi

= 10.335 bar

= 1.033 MPa

Peak Positive Reflect Velocity

P_r = 700 psi

= 48.23 bar

= 4.823 MPa

Shock Front Velocity

From appendix – 1, we need to observe the value of shock front velocity for obtained scaled distance i.e. $2.621 \, {}^{ft}/_{lb^{1/3}}$

U $= 4 \, ft/ms$ (From Appendix - 1)

$= 1219.2 \, m/s$

Unit Positive Incident Impulse

From Appendix - 1 we need to observe the value of unit positive incident impulse for obtained scaled distance

i.e. $2.621 \, {}^{ft}/_{lb^{1/3}}$

${}^{i_s}/_{W^{1/3}} = 25 \left[psi - ms/lb^{\frac{1}{3}}\right] \, (from \; appendx - 1)$

i_s = 0.0010961 Ps

Duration of Positive Phase of Blast Pressure

From Appendix – 1, we need to observe the value of Duration of positive phase of blast pressure for obtained scaled distance i.e. $2.621 \, {}^{ft}/_{lb^{1/3}}$

${}^{t_o}/_{W^{1/3}}$

$= 0.5 \left[ms/lb^{\frac{1}{3}}\right] \, (from \; appendix - 1)$

t_o = 187.7279 ms

= 0.187728 s

Time of Arrival of Blast Wave

From Appendix – 1, we need to observe the value of time of arrival of blast wave for obtained scaled distance i.e. $2.621 \, {}^{ft}/_{lb^{1/3}}$

$$t_A / W^{1/3} = 0.4\ \left[ms/lb^{\frac{1}{3}}\right]\ (from\ appendix - 1)$$

t_A = 150.1823 ms
= 0.150182 s

5. RESULTS

The free air burst parameters of the nuclear explosion are as follows

Peak Positive Incident Pressure (P_{so})	1.0335 MPa
Time of Arrival of Blast Wave (t_A)	150.18 ms
Positive Phase of Blast Pressure (t_0)	187.73 ms

6. CONCLUSIONS

The aim in the blast resistant layout is to save you the general collapse of the building and deadly damages. Despite the fact that, the importance of the explosion and the hundreds due to it cannot be predicted flawlessly, the most feasible situations will let to find the important engineering and architectural solutions for it.

In the design technique it is essential to determine the potential threat and the volume of this chance. Most importantly human protection need to be provided. Furthermore, to obtain practical continuity after an explosion, architectural and structural factors ought to be taken into consideration in the design system and a most fulfilling constructing plan ought to be put together.

During the architectural design, the conduct underneath intense compression loading of the structural form, structural elements instance partitions, flooring and secondary structural factors like cladding and glazing should be taken into consideration carefully. In traditional layout, all structural factors are designed to resist the structural masses. But it needs to be remembered that, blasts hundreds are unpredictable, on the spot and severe. Therefore, its miles obvious that a building will receive less damage with a particular safety stage and a blast resistant architectural layout. However, those sorts of buildings will much less entice the terrorist attacks.

Structural design after an environmental and architectural blast resistant design, as well stands for a first rate significance to prevent the general fall apart of a constructing. With correct selection of the structural machine, well designed beam – column connection, structural factors designed appropriately, moment frames that switch sufficient load and excessive great cloth; it's possible to construct a blast resistant constructing. Every single member should be designed to endure the possible blast loading. For the present systems, retrofitting of the structural factors is probably important. Although those precautions will boom the value of creation, to defend unique buildings with the terrorist assault threat like embassies, federal homes or alternate centres is unquestionable.

REFERENCES

[1] ***Army Technical Manual 5-858-5 (Department of the Army, 1983)*** – This manual is intended for use by engineers involved in designing hardened facilities to resist the effects of nuclear weapons.

[2] ***ASCE Manual 42 (1985)*** – This manual was prepared to provide guidance in the design of facilities intended to resist nuclear weapon effects. It presents conservative design ductility ratios and flexure response.

[3] ***Assal T. Hussein*** studied about the analytical methods of a SDOF system analysis subjected to blast loadings. Two types of blast wave applied for study of the non-linear behavior of system, the

analysis focused on the displacement time history responses which form the basis for studying behaviour of SDOF system under blast loadings.

[4] ***C.K Gautam and R.C Pathak*** designed a shock/blast resistant structure and experimentally evaluated. The structure, capable of withstanding dynamic loading due to blast or any other explosion, also gives protection against radiation, chemical and thermal hazards.

[5] ***FEMA Guidelines*** – This publication is not a technical or design manual, but it contains clear and comprehensive guidelines on issues that need to be addressed and simple explanations of such steps. This may be the most effective starting point for people who wish to learn how to handle protective construction projects.

[6] ***IS 4991 (1968):*** - Criteria for blast resistant design of structures for explosions above ground.

[7] ***Leon Chernin et al.*** studied and presented an analytical procedure allowing the prediction of the blast dynamic response of a beam-column to a combined action of axial and transverse loads using continuous formulation and the Euler-Bernoulli beam theory. The analysis shows that the number of modes of vibration needed to produce an accurate estimate of the beam-column behaviour may vary depending on the loading regime. The results obtained by the analytical model are compared to the results of a non-linear finite element analysis performed in ABACUS.

[8] ***Makovicka D et al.*** studied the assessment of structure loaded by explosion of terrorist charge. Evaluations of structures loaded by an explosion based on dynamic displacement and rotation round the central line of plate, wall or beam system during the action of a dynamic load of this type have been very typical interest in recent times as regards the process of evaluating the effects of an explosion on a structure.

[9] ***SajalVerma et al.*** studied to review the various methods applied to different types of structures such as masonry, concrete, steel and the effectiveness of each method. The Indian code does not have enough provisions for dealing with blast load, so it is important to study the properties of blast loading as dynamic loading. The author discussed various methods like FRP retrofit technique in masonry walls, unidirectional passive dampers in steel structures, varying core density in sandwich structures and composite materials.

[10] ***Tanaz Rahaimzadeh et al.*** studied how layers of elastic and visco-elastic materials may be assembled to mitigate these features. The features of blast and impact that can damage a delicate target supported by a structure include both the peak pressure and impulse delivered to structure. The impedance mismatch between two elastic layers is known to reduce pressure, but dissipation is required to mitigate the transmitted impulse in light weight armor. A novel design concept called impact or blast tuning is introduced in which a multi-layered armor is used to tune the stress waves resulting from an impact or blast to specific frequencies that match the damping frequencies of visco elastic layers.

[11] ***Tri-Service Manual TM 5-1300 (Department of Army, 1990)*** – This manual is intended primarily for explosives safety applications. It is the most widely used manual for structural design to resist blast effects. One reason for its wide spread use by industry is that it is approved for public release with unlimited distribution. On the basis of purpose of the structure and design range, the allowable design response limits for the structural elements (primarily roof and wall slabs) are given as support rotations. This publication is most widely used by both military and civilian organisations.

[12] ***UFC 3-340-02*** – UFC presents methods of design for protective construction used in facilities for development, testing, production, storage, maintenance, modification, inspection, demilitarization and disposal explosive material.

[13] ***Vijayaraghavan et al.*** studied about the nuclear blast overpressure on buildings by using remote sensing and geographical information system and created a model city for analyzing the effects of yield of the nuclear bomb of different capacities from 10kt to 20kt and introduced different empirical methods to estimate blast loads and structural response empirical methods

APPENDIX - 1

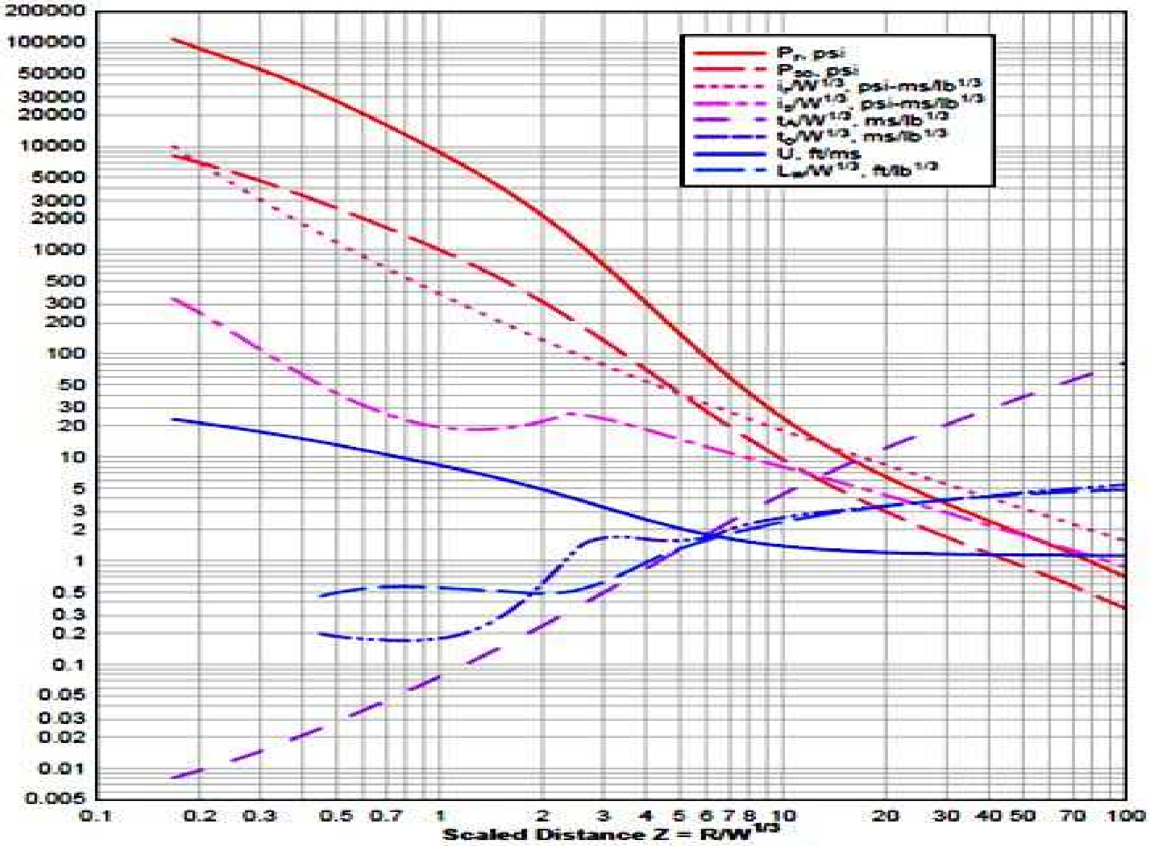

Figure 3 Positive Phase Shock Wave Parameter for a Spherical TNT Explosion in Free Air

BIOGRAPHIES

D. Yogeswar, M.Tech, Student, Computer Aided Structural Engineering, JNTUA College of Engineering, (Autonomous), Anantapuramu, Andhra Pradesh, India

Dr. C. Sashidhar, Professor, Department of Civil Engineering, JNTUA College of Engineering, (Autonomous), Anantapuramu, Andhra Pradesh, India